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# Nyssa sylvatica Marsh.

THEO. HOLM.

[*With 16 figures drawn by the author.*]

The genus *Nyssa* is now confined to North America (southern Ontario and the eastern United States), where three species are distinguished, and to southern Asia, where a single species is distributed from the eastern Himalayas to the island of Java. *Nyssa sylvatica* Marsh, *N. Ogeche* Marsh, and *N. aquatica* L. are the American species, familiarly known as Tupelo, Pepperidge, Black or Sour Gum. They are deciduous trees with unisexual flowers, and alternate leaves, and very distinct from *Cornus* and *Garrya*, the only other members of the *Cornaceæ* represented in our country.

While excellent illustrations and very detailed descriptions of these *Nyssae* are to be found in Sargent's Silva of North America there are still some points of interest to be noticed, which have not, so far, been recorded, and which may deserve attention. A comparative study of the three American species would, of course, lead to better results than the consideration of only one of these, but since *N. sylvatica* is the only species occuring in this vicinity, I am compelled to confine myself to this species, hoping that the present notes may serve as a small contribution to the knowledge of this, in many respects, very peculiar tree.

Characteristic of the mature tree is the frequently very broad and flat top, the crowded horizontal to pendulous branches, and the very short, stout, lateral branchlets, not speaking of the bright, crimson color of the foliage in Autumn. The leaves are generally described as entire, in contrast with the frequently remotely and irregularly angulate-toothed ones of *Nyssa aquatica.* Sargent (l. c.), however, states that they are "rarely coarsely dentate", while Bentham and Hooker describe them as "integerrima or juniora lobato-dentata." Of these statements the latter is the more correct.

In studying the foliage of trees, which in many of our native species offers a multitude of forms, especially in regard to outline, it is necessary to include the younger stages, and if possible, the seedlings. Not only is the manner of germinating of some interest, but also the structure and shape of the first leaves succeeding the cotyledons, since these, the so-called primary leaves, evidently represent the foliage of ancestral types, a point that has been discussed and explained in *Quercus*, for instance.

Now in regard to the *Cornaceae*, *Aucuba japonica* is the only one of which the seedling-stage has been described by Lubbock in his comprehensive work on seedlings, and none are mentioned by Klebs.* In the seedling of *Aucuba* the primary root is stout and fleshy; the hypocotyl is quite long, and the cotyledons oblong-ovate, obtuse, three or five-nerved, shortly petiolate. The first pair of leaves are ovate, while the second and third pairs are reduced to small, subulate scales preceding the ultimate, which are ample, lanceolate-oblong, distinctly serrate-dentate on the upper half, and alternately penni-nerved. In *Cornus florida*† the primary root is rather slender, the hypocotyl erect, and the cotyledons green and foliaceous; the primary leaves resemble those of the mature tree, but are, however, held in a vertical position, and are somewhat narrower than the typical leaves. A very similar structure is represented by the seedling of *Nyssa*, or to be more exact of *N. sylvatica*, since the seedlings of the other species are not known so far. In this species of *Nyssa* (Fig. 1.) the primary root (R) is long, very slender and amply ramified, especially at the base, beneath the hypocotyl (H). This organ, the hypocotyl, is erect, but slender and bears two green, oblong cotyledons, which are obtuse, and approximately five-nerved; (Fig. 2.) the following internodes are stretched, and the leaves of the first season vary from elliptic with entire margins to obovate with the margins dentate. The foliage of the seedling, thus, differs in a marked degree from that of the mature tree, which we remember is mostly oval or obovate, and always with the margins entire. In the second season we meet with a single, erect shoot with remote leaves and with the primary root developed as a strong, very long, deep root; we observed at this stage the same variation in foliage, as a matter of fact it recurs for several years so long as the plant is a mere shrub, but ceases when it becomes a tree. In other words the dentate leaves characteristic of *N. aquatica* occur, also, in *N. sylvatica* before it reaches maturity. It would be interesting to know whether this be the same case of *N. Ogeche*, of which only the entire leaf is recorded.

This peculiar variation in regard to the foliage, with the margins entire or dentate, does not depend upon the position of the leaves, and is almost as striking as the well-known heterophylly in *Sassafras*, where lobed and entire leaves appear on the same shoot with no indication of any special arrangement. So far as concerns our *Nyssa* I can only say that the dentate leaves occur occasionally on the seedlings during the first season, that they are very frequent on the young shrubs, where they are equally as common on the long, vigorous shoots as on the short, lateral branches of these; but, so far, I have not observed any such dentation of the leaves on the root-shoots of *Nyssa*. The accompanying figures 3–6 illustrate the foliage of a single lateral branch, of which figure 3 shows the basal, figure 6 the apical of these leaves; figure 7 represents a larger leaf from a tall shrub, and the dentation is very pronounced. It generally appears as if the dentate leaves are larger than the entire; it is, for instance, not uncommon to find dentate leaves measuring up to fifteen cm in length, while the entire on the same branch may reach only nine or ten cm, or much less. Another point, not to be left out of consideration, is the noticeable difference in outline between these two types of leaves. While the dentate are always obovate, the entire vary from lanceolate to oval, obovate, the oval being perhaps the most frequent of the mature tree, and the obovate that of the seedling.

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* Untersuchungen aus d. bot. Inst. Tuebingen I: 536. 1881–1885.

† Merck's Report for Dec. 1909.

In passing to describe the internal structure of the vegetative organs as observed in *Nyssa sylvatica*, it must be stated beforehand that the stem and leaves of the *Cornaceae* have already been studied by various authors, while the root, as is generally the case, has been neglected. A very complete treatment of the family from an anatomical point of view has been presented by Solereder in his work, *Systematische Anatomie der Dicotyledonen*.* In this treatment, however, the leaf and the stem of the mature tree only have been examined, thus we conceive no comparison between the various stages of growth, and no information about the root-structure. The ample material which I have had the opportunity to study enables me to present some supplementary notes, beside a description of the root-system as represented in the seedling and mature tree. Let us begin with the root.

### THE ROOT.

So long as the cotyledons are the only leaves developed upon the seedling the primary root shows a very simple structure, and with no indication of increase in thickness. At this stage it is unbranched, and very little hairy. The only peculiarity, which may deserve mention, consists in the presence of a broad pith. Beside that the hadromatic rays are very short and separated by broad arches of leptome; otherwise the structure is very simple. The cortex is homogeneous, there being no exodermis and no stereïds, but about ten strata of thinwalled parenchyma, very compact, and with no deposits of starch. Endodermis is, also thinwalled with the Casparyan spots plainly visible, and the pericambium is continuous represented by a single layer; the stele is tetrarch. Later on when the seedling is at the stage shown in the accompanying figure 1, the root has commenced to branch, and has increased considerably in length. At this stage the internal structure is changed, and to such an extent that the pith and the primordial vessels are the only tissues left intact. Epidermis is now partly thrown off, nearly the whole cortex is collapsed so as to form wide cavities, and the thickened endodermis shows here and there radial divisions. Inside endodermis we notice a broad secondary cortex, developed from the pericambium surrounding a solid stele of collateral mestome-strands and a central pith, at the periphery of which the four primordial hadrome-rays are still to be recognized. Starch was observed in the narrow (one row) medullary rays, but no crystals of calcium oxalate. In regard to the lateral roots, borne upon the primary, the structure agrees with that of the mother-root before the secondary formations set in; these are, however, also capable of increasing in thickness, but much later than the primary.

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* Stuttgart 1899 page 487.

A still more modified structure occurs in the thick, woody roots of the mature tree. In these all the primary tissues from epidermis to endodermis incl. are lost, but replaced by a heavy coating of homogeneous, thickwalled cork of pericambial origin, which encloses a broad secondary cortex with aggregated crystals of calcium oxalate, deposits of starch, and interspersed with groups of thickwalled, porous sclereïds. The stele is very broad, with numerous wide tracheids, thickwalled parenchyma and libriform; the medullary rays are thinwalled, and consist mostly of a single or two rows of radially stretched cells, containing starch.

While thus the root of our *Nyssa* illustrates the general structure of the dicotyledonous type so far as concerns the primary and secondary stages, the presence of crystals and sclereïds in the secondary cortex is of some interest.

## THE STEM.

The hypocotyl, the first internodes of the seedling, the branches of the mature tree, and finally the peduncle of the female inflorescence, these represent portions of the stem of which the structure must be considered in order to obtain a complete view of the internal morphology of this organ. To ascertain the primary structure of the stele the hypocotyl is especially instructive, while the older branches of the tree show us the tissues in their final shape with the secondary formations. In regard to the origin of the secondary mestome-strands, we remember that these most frequently develop from interfascicular cambium, or from a procambium*; however, several and very distinct modifications are known, more so from herbaceous than from woody stems, and some of these structures may be quite complicated. As regards the peripheral tissues these are, also, more or less involved and subject to change, when increase in thickness takes place, hence a comparison between young and mature shoots becomes necessary. In beginning with the hypocotyl of the seedling ( Fig. 1 ), we notice at once that all the peripheral tissues are preserved although the stele shows already a marked increase so as to obscure its primary structure. Viewed in cross sections the stele represents a solid circular zone of leptome, cambium and hadrome enclosing a homogeneous, thinwalled pith, and this structure exists from the subterranean base to the apex beneath the cotyledons. In the basal portion it is very difficult to locate the primary mestome-strands, while toward the apex their position becomes readily noticeable by the presence of stereomatic strands in the pericycle, and by the primary vessels being more distinct, relatively narrow and of a darker color than the others. There are, thus, in all eight primary mestome-strands in the hypocotyl which traverse this parallel with each other and with the surface. But how these primary strands become connected with each other must be studied from a still younger stage than the one figured (Fig. 1.) We must examine the seedling before the cotyledons have ceased to grow, and before the plumule has developed into a shoot of several internodes. At this stage the stele shows very plainly eight primary collateral mestome-strands separated from each other by strata of thinwalled parenchyma (Fig. 8.); or at a

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* Sachs: Lehrbuch der Botanik. Leipzig 1874 p. 113. Haberlandt: Physiol. Pflanzenanatomie. Leipzig 1896, p. 491.

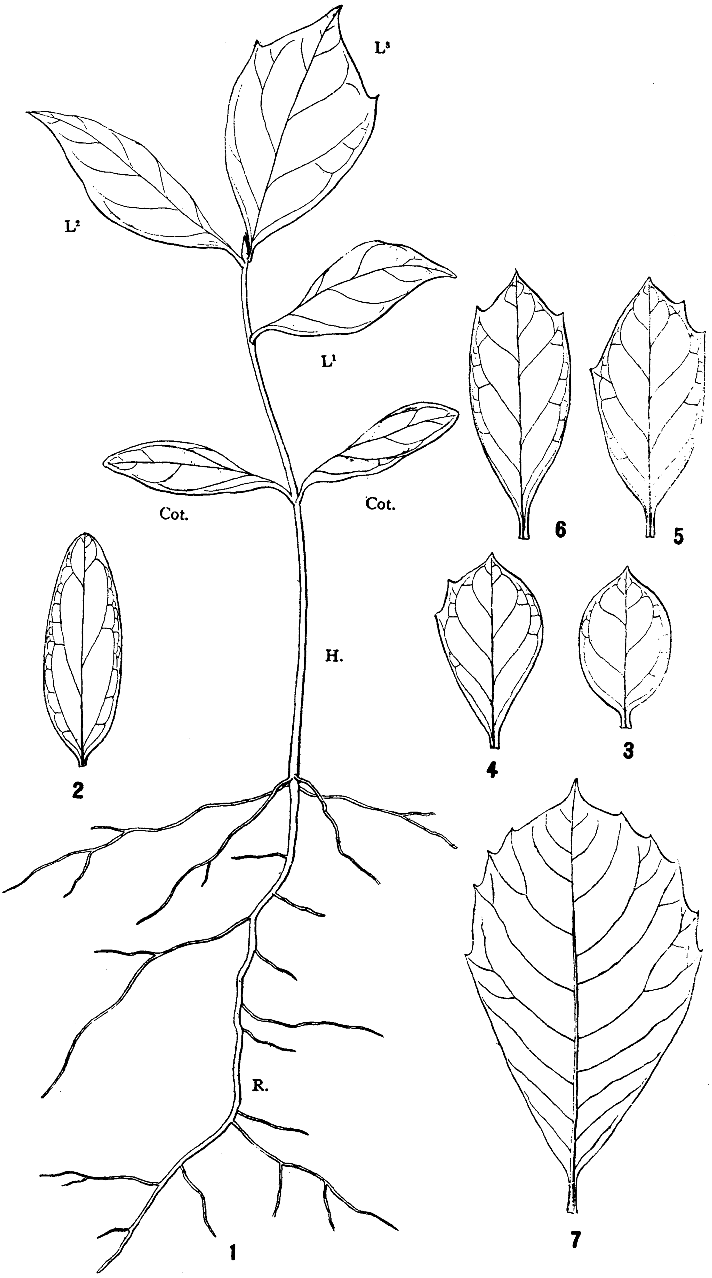
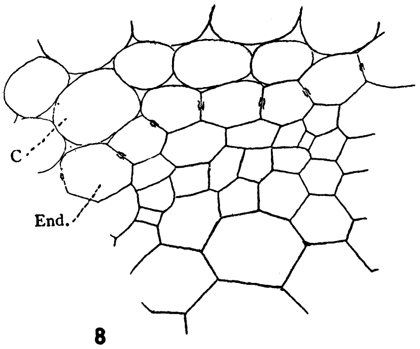


*PLATE IX.* HOLM on NYSSA SYLVATICA.



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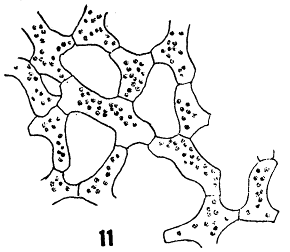

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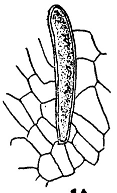

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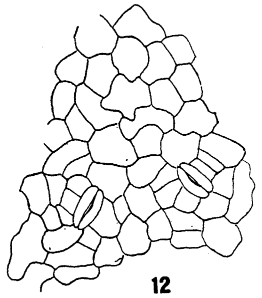

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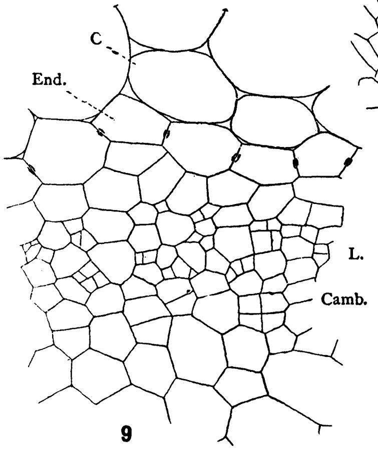

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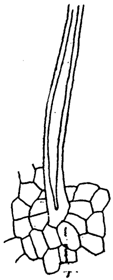

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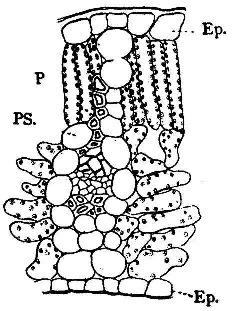

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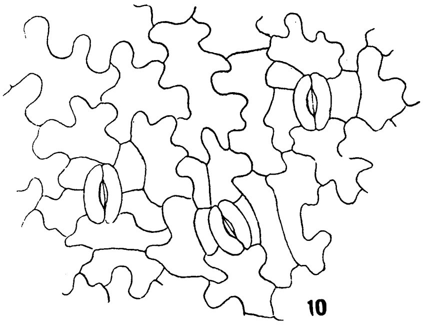

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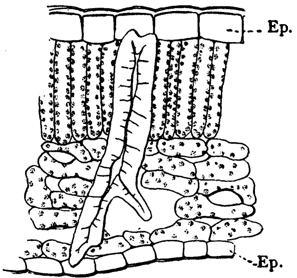

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*PLATE X.* HOLM on NYSSA SYLVATICA.

somewhat more advanced stage (Fig. 9.) we notice in this parenchyma a beginning development of leptome (L. in fig. 9.) beside tangential divisions, indicating the origin of an interfascicular cambium in direct connection with the primary intrafascicular. It is from the interfascicular cambium that the secondary leptome and hadrome become developed, rapidly increasing in thickness so as to equal the primary. In regard to the other tissues of the hypocotyl we might mention that near the base the cuticle is thin and smooth; covering a small-celled, thinwalled epidermis destitute of hairs. Furthermore that the cortex is homogenous, thinwalled, frequently collapsed, and that the hypodermal stratum shows a formation of cork. There is a distinct endodermis, thinwalled, but readily noticeable by the Casparyan spots, and inside this sheath is a thinwalled pericycle, which in the apical portion of the hypocotyl becomes stereomatic, but as already indicated only outside the primary leptome. Near the cotyledons the epidermis becomes thickwalled with the outer cell-wall extended into minute longitudinal crests, and the cortex is here solid, not collapsed. No crystals of calcium oxalate were observed in any parts of the hypocotyl. A somewhat modified structure occurs in the first internode of the same seedling (Fig. 1.) In this the cortical parenchyma consists of collenchyma near epidermis, while the internal strata are thinwalled and contain large, single crystals of calcium—oxalate, besides some aggregates of the same substance. There is no endodermis, but a pericycle of isolated strands of typical stereome surrounding the stele.

The seedling, thus, illustrates the primary structure and certain parts of the secondary, not only within the stele, but also near the periphery, when the cork has already made its appearance.

If we now examine branches of the mature tree, we meet with a much firmer structure; the cork represents here numerous and very thickwalled strata, covering a cortex which is collenchymatic throughout, and rich in chlorophyll; then follows the pericycle of thickwalled stereome intermixed with large, porous sclereïds, forming a closed sheath around the stele. In this the secondary hadrome contains scalariform vessels, porous tracheids with bordered pits, and much thickwalled libriform; the medullary rays are single with the cells stretched radially and filled with starch. The centre of the stele is occupied by a heterogeneous pith, starch-bearing and active in the periphery, but empty in the centre. A corresponding structure recurs in the peduncle, when the fruit is ripe. However, the epidermis persists and is very thickwalled. There is no cork, and the cortex is collenchymatic throughout, the pericycle is very strongly developed with heavy layers of stereome and sclereïds, while the stele is narrow, surrounding a thickwalled, starch-bearing pith.

The mechanical tissues, collenchyma and stereome, are thus well represented in the stem of *Nyssa*, the former pertaining to cortex, the latter to the pericycle, or inside the hadrome as libriform. It is, also, of some interest to notice the superficial cork, and the occurrence of calcium oxalate as single or aggregated crystals in the cortical parenchyma.

## THE LEAVES.

When cotyledons are aerial and foliaceous* they generally assume the same, or approximately the same structure as the leaves proper. They are mostly glabrous, however, and the chlorenchyma, sometimes, shows a less pronounced differentiation as palisade and pneumatic tissue, beside that the veins are frequently embedded and not projecting on the dorsal face. In speaking of *Nyssa sylvatica* the cotyledons do in some respects, possess a structure, which is rather distinct from that of the mature leaf of the tree, but not so much from that of the primary leaves, which I have drawn in figure 1 ($L^1$-$L^3$).

The principal distinction consists in the structure of the epidermis which, on both faces of the blade, exhibits undulate lateral cell-walls (Fig. 10), while in the leaves of the tree, these walls are nearly straight (Fig. 12) ; another distinction consists in the much larger size of both stomata and epidermal cells in the cotyledons, when compared with the mature leaves; this may be readily seen from the figures (Figs. 10 and 12) which are drawn to the same magnification. There are no hairs, and the leaf-structure is bifacial with a ventral palisade tissue, and a dorsal pneumatic. The midrib contains a single collateral mestome-strand surrounded by a thin-walled, barely stereomatic pericycle and a parenchyma of thinwalled cells destitute of chlorophyll; the secondary and tertiary veins are completely embedded in the chlorenchyma and provided with typical parenchyma-sheaths; no idioblasts and no crystals were observed in these leaves.

The short petiole is, also, somewhat different from that of the mature leaves of the tree, since the mestome-strands (about seven) are arranged in a plane instead of in a stele. If we examine the primary leaves ($L^1$—$L^3$ in figure 1) we notice exactly the same structure of epidermis as to lumen and shape as described under the cotyledons. These primary leaves, however, are hairy, and the veins show the same simple structure as observed in the cotyledons. No crystals were found and no idioblasts either, although such occur in the petiole of the same shape as in the final leaves.

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* Merck's Report Dec, 1909.

The foliar structure characteristic of the species is, however, the one possessed by the leaves of the mature tree. These are during the summer held in a horizontal position, and their structure is bifacial with stomata confined to the dorsal face, and with a ventral palisade-tissue. Very distinct cuticular striations are noticeable on both faces of the blade, but only the dorsal is hairy with small glandular (Fig. 14), and very long pointed hairs (Fig. 13), unicellular in both. The stomata (Fig. 12) have, sometimes, subsidiary cells parallel with the stoma, but are much smaller than those of the cotyledons and primary leaves. As already mentioned the lateral cell-walls of epidermis are nearly straight (Fig. 12), and the outer is thinwalled except beneath the midrib. The palisade cells represent a single layer, and are very high (Figs. 15 and 16), covering a few (about six) strata of irregularly branched cells constituting a pneumatic tissue with very wide intercellular spaces, which are especially noticeable in superficial sections (Fig. 11). We find in the chlorenchyma numerous idioblasts (Fig. 15), very thickwalled and porous representing the so-called sclereïds. These peculiar cells are known, furthermore, from species of *Garrya* and *Griselinia*, and they show translucent dots when the leaf is held towards the light. The midrib has a dorsal keel with hypodermal collenchyma and a large tissue of thinwalled, colorless parenchyma, but lacks endodermis; there is, on the other hand, a thickwalled stereomatic pericycle covering the leptome-side of the two separate mestome-strands which constitute the midrib. These two strands turn their leptome towards the surface of the blade, thus the hadrome is in the centre enclosing a small pith. Of these the dorsal strand is the larger; it is crescent-shaped (in cross-section) and contains leptome, cambium and relatively long rays of vessels. All the other veins are provided with distinct parenchyma-sheaths (P. S. in fig. 16) and are connected with both epidermes by strata of thin-walled parenchyma; they are frequently supported by a little stereome on the hadrome-side. No crystals were observed in the blade of any of these leaves.

In regard to the petiole which often exhibits a structure characteristic of certain species, when examined just beneath the leaf-blade, we find in our *Nyssa* a large stele composed of six mestome-strands of the same structure as those in the midrib. A cross-section of the petiole shows a hemicylindric outline; epidermis is hairy and very thickwalled with wrinkled cuticle on the vertical face, and there are several, about six, hypodermal layers of thick-walled parenchyma with the stele. In this parenchyma large single and aggregated, globose crystals of calcium oxalate are quite abundant, beside some few idioblasts, very conspicuous by their enormous size and stellate shape. There is no endodermis, but a stereomatic pericycle on the leptome-side of all the mestome-strands. The selereids, the peculiar, small glandular hairs and the mestome-strands being connected with epidermis, these characters together may be of taxonomic importance. In *Cornus florida* for instance * there are no glandular hairs, only long, bifurcate, and no sclereïds; furthermore the lateral veins are embedded in the chlorenchyma. But otherwise so far as concerns the internal structure the *Cornaceæ* offer no well marked characters by which we might distinguish the genera or the species; on the other hand we must admit that our knowledge of this particular part of the structure is, at present rather limited, not speaking of the root-system and the seedling-stage with the primary leaves. To the diagnosis of the species *N. sytvatica* should be added that the leaves of young specimens are frequently dentate like those of *N. aquatica* Marsh.

Fig. 1. Seedling of *Nyssa sylvatica* Marsh. R, the primary root; H, the hypocotyl; Cot., the two cotyledons; $L^1$, $L^2$ and $L^3$, the primary leaves; natural size.

Fig. 2. One of the cotyledons, showing the venation; natural size.

Fig. 3. Leaves of a shoot from a shrub; two thirds of the natural size.

Fig. 7. Leaf from a shrub, showing the dentate margin; two-thirds of the natural size.

Fig. 8. Cross section of hypocotyl; C, cortex; End., endodermis;x496.

Fig. 9. Cross section of hypocotyl; Camb, cambium; L., leptome; the other letters as above; x496.

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* Aerial, nonfoliaceous cotyledons exist, but are evidently very rare; they occur in Jatropha (Bot. Gazette 1899 p. 60).

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| Fig. 10. | Dorsal epidermis with stomata of cotyledon;x320. |
| Fig. 11. | Pneumatic tissue of same; x320. |
| Fig. 12. | Dorsal epidermis with stomata of a leaf from a tree;x320. |
| Fig. 13. | Base of a long, unicellular, pointed hair of same;x320. |
| Fig. 14. | Glandular hair of same;x320. |
| Fig. 15. | Cross-section of leaf from a tree, showing a large idioblast in the chlorenchyma; Ep.,* ventral, Ep., dorsal epidermis; x320. |
| Fig. 16. | Cross-section of same leaf, showing a lateral vein with colorless parenchyma, stereome, and parenchyma-sheath, [P. S.); P, palisade tissue; the other letters as above; x320. |

*Brookland, D. C.*

# Book Notices.

## A NEW HISTORY OF BOTANY

There is not yet extant in the English language any work, or even the beginnings of any work, that is of the nature of a history of botany from the earliest times down to the present. For such history of botany in general as we have we are indebted to the zeal and learning of Frenchmen and Germans of the eighteenth century and the early nineteenth; and these attempts are partly in French, partly in German, and the best of them are in Latin.

There is now in the press in this country, and under the auspices of the Smithsonian Institution at Washington, the first volume of a work in English bearing the title of *Landmarks of Botanical History;* an enterprise undertaken by Doctor Edward L. Greene, an Honorary Associate of the Institution.

The plan of this forthcoming work, as the title implies, is that of a careful study and plain elucidation of principal epochs in the development of the science from the earliest period. Such treatment of a subject as ancient as botany, having a literature so vast, and having undergone so many vicissitudes of advance and retrogression during more than two milleniums, can not by any possibility be reduced to the limits of a single volume, but must fill two or three at the least; and that which it is promised we soon shall see is but a first instalment, and not a very large one, of the *Landmarks;* but as replete with a great number, and much diversity of facts never before presented in any history of botany, that it fills